Overcoming the Tipping Point Through Service Innovation. An Overview of the Smart City

Francesco Polese and Antonietta Megaro

Abstract This conceptual paper aims to understand what can allow smart cities, considered as service ecosystems, to effectively face the important challenges and uncertainties of our time, such as the energy crisis, by adopting the phase transitions interpretative lens. To reach this purpose, a literature review on smart cities and phase transition in a service ecosystem perspective has been carried out to merge their main concepts through the 'integrating' method for providing researchers and practitioners with suggestions on this topic observed in a new perspective. However, by using the phase transition perspective, the severity of the current energy crisis could represent a tipping point for smart cities and foster fluctuations difficult to absorb and system destabilization and de-institutionalization. Service innovation perspective can be considered as a driver to enable smart cities to react quickly and effectively to unforeseen changes. An example can be found in the digital twin city that would allow policy-makers to remotely monitor the behavior of the real city, plan and develop projects by first observing its effects on the virtual twin to not waste resources, anticipate any problems and carry out corrective actions in a predictive manner, in order to effectively navigate the transition and move towards a re-stabilization through new institutional arrangements. Thanks to this study, smart cities' policy-makers and scholars can design new city patterns based on smart technologies to pursue viability and resource waste reduction conditions, despite the change.

Keywords Phase transition · Tipping point · Institutional arrangements · Service ecosystem · Smart city

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1 Introduction

The term smart city refers to a city based on the integration of traditional infrastructures and new digital technologies [1], especially related to advanced data processing, with the aim of pursuing a general improvement in terms of more efficient governance, happier citizens, more sustainability [2]. The analysis and effective use of big data allows to achieve the required level of sustainability and improve living standards; it is therefore considered a key factor for the success of smart cities [3]. Through integration, analysis and vitalization of this data, researchers can study and design more efficient and smarter urban applications or systems from a general city perspective [2]. Even if smart cities are born to promote energy efficiency and increase the well-being of citizens, the seriousness of the current energy crisis, mainly due to the war in Ukraine, has determined a reduction in the energy provision against an increase in its demand. Such a condition could represent a tipping point for smart cities because it can favor fluctuations difficult to absorb. For this reason, there could be the need to develop new, and increasingly performing, technologies to allow cities to converge rapidly towards re-institutionalization, after de-institutionalization. The analysis of the smart city according to the service ecosystem perspective has already been developed in the literature but not widely debated; even less analyzed the development possibilities of smart cities, intended as service ecosystems, according to the phase transition lens. To fulfill this gap, this conceptual paper tries to answer the following research question.

R.Q.: what can allow smart cities, considered as service ecosystems, to effectively face the important challenges and uncertainties of our time, such as the energy crisis?

The paper starts with the description of the theoretical background (Sect. 2) in order to outpoint such common elements which, analyzed by using the integrating method (Sect. 3), allow an investigation of the phenomenon from a new perspective. This new perspective makes it possible to identify a possible solution to the problem posed (Sect. 4), also clarified through the presentation of an illustration case (Sect. 5). The paper ends with non-conclusive considerations (Sect. 6).

2 Theoretical Background

2.1 Smart Cities

To effectively understand the *smartness* of a city, attention must not be focused only on the technology adopted but it is necessary to evaluate how much these technologies improve the interactions between the city and its people. In fact, the citizen's point of view, his awareness of smart applications and solutions and his ability to use them, become increasingly central in the debate on smart cities. Even the most educated users of smart services city and therefore probably more aware and skilled to use them properly, express concerns about the usefulness, safety, accessibility and efficiency

of these services [4]. For this reason, research on smart cities must increasingly be focused on the real and tangible experiences of people who live and can influence the design and implementation processes of smart cities development policies [5] more than merely on the most performing technologies. Technology should not be understood as a goal but as an asset capable of improving the user experience [6]. The role of users, and their active participation, is functional for the achievement of high-level performance within the smart city: the main advantages refer to a greater value perceived by them and therefore to greater opportunities for value co-creation in smart cities [7]. Citizens should therefore be included in the smart city discussion and involved in the co-design of smart city solutions and urban planning decision-making [8]. Using the co-creation of value as a relevant driver and adopting a systemic perspective, smart cities have been analyzed as complex service systems with the aim of investigating the ways in which the perceptions and willingness of the actors influence the opportunities to co-create value and to design collaborative paths [9], and as smart service systems [8] to focus on services that could also be smart and become levers through which smart cities grow, develop and build their resilience[10], understood as a purpose of smart cities [11, 12]. Also useful is the ecosystem vision that allows for an integrated analysis of technologies, resources and value co-creation practices to find out how to pursue sustainability objectives in the context of a smart city, taking into account that the main drivers for pursuing the *smartness* of a smart city are: technologies, human components and institutional dimensions (intended in terms of governance) [13].

2.2 Service Ecosystem Phase Transition

Social and socio-technical systems can undergo phase transitions [14] and this happens when external environmental disturbances and internal interactions interrupt their equilibrium causing them to pass from one state of stability to another [15]. The phase transition in a market, for example, is determined when the character of a market, and its role in the creation of value, as well as the behavior of the companies that interface with it, change [16]. The service ecosystem perspective allows the investigation of the dynamics underlying value co-creation, understood as a systemic property and order parameter, characterized by various systemic principles, including phase transition [17]. Service ecosystems are dynamic, emerging, complex and self-organizing systems, made up of actors, nested within three levels, micro, meso and macro [18], who integrate resources [19], according to shared institutions [20], intended as tacit rules, symbols and meanings [21], and connected by value propositions, with the ultimate aim of co-creating mutual value through the exchange of service [22]. The set of institutions makes up the institutional agreements that favor coordination between the different service ecosystem levels. The key elements of a service ecosystem are institutions, actors, resource integration, technology, value propositions and actors [13]. The representation of service ecosystems in the form of phase transition considers that exchange, considered as result of

resources integration, and collaboration, as process of resources integration, are both important to make the service ecosystem stable [23]. The self-organizing processes of service ecosystems are analogous to phase transitions in equilibrium for which value can be co-created by enhancing the changes [19] which should tend to the adaptability of these systems occurring through the institutionalization of new practices of resource integration [24]. Polese et al. [15] analyzed the phase transition concerning service ecosystems: it occurs when there is deinstitutionalization, due to internal or external perturbations that destabilize the ecosystem and bring it closer to the tipping point that involves structural changes and behavioral aspects of the system, and ends with a re-institutionalization, characterized by new stability thanks to new institutional arrangements. The tipping point has been defined as a dramatic moment in which everything can change with respect to a specific situation that could undergo drastic changes, not easily undone, and lead, indeed, to the creation of a new system [25].

3 Critical Review of the Literature

To address the research question, it was developed a conceptual study following the integrating method [26]. Integrating makes it possible to analyze a phenomenon from a new perspective, using what is already known and theorized in the literature, transforming it into something new, simplified and of a higher order than the earlier differentiated entities and now correlated.

3.1 Integrating: Phase Transition in Smart Cities as Service Ecosystems

Smart cities are based on the application of smart technologies to cities to reduce energy consumption and, at the same time, improve citizens' quality of life. However, by using the phase transition perspective, the severity of the current energy crisis could represent a tipping point for smart cities and foster fluctuations difficult to absorb and system destabilization and de-institutionalization. In order to understand how smart cities can address and overcome this tipping point, the integration method is used which, by seeking similarities between the smart cities and service ecosystems literature, makes it possible to analyze them from a new perspective. Key dimensions of service ecosystems emerged from the previous literature review: institutions, considered as coordination mechanisms for exchanges, based on preexisting shared rules that act as enablers of resource integration; actors that are generic users reframed as value co-creators; resource integration, considered as an exchange of resources occurring in the multiple interactions between actors; technology intended

as tools that make exchanges more efficient and enable innovation; value proposition, as set of common values that guide the attainment of shared purposes for each actor [13]. Main drivers for the smartness of a smart city are technologies, human components and governance/institutional dimensions [13]. Furthermore, the phase transition occurs when a service ecosystem undergoes deinstitutionalization and ends with a re-institutionalization through the definition of new institutional arrangements. To understand how to deal with the phase transition and overcome it, we believe it may be useful to focus attention on the elements in common between the two phenomena described above, which contribute to the emergence of a service ecosystem and make a smart city effective. The elements in common between the two theoretical constructs are technologies and human components/actors.

4 Service Innovation to Design Smart Cities Able to Get Better of Unforeseen Changes

To understand what can enable smart cities to effectively overcome fluctuations, difficult to absorb and potentially destabilizing, due to de-institutionalization processes, through a rapid re-institutionalization, in the previous paragraph it was considered necessary to focus on the role of new technologies and actors to enable new institutions. In the literature, technologies, actors and new institutions have already been treated in an integrated way in the service innovation field. In fact, the technology, although is a critical resource for value co-creation and systems (re)formation [27], to be useful and to allow new institutions and a re-institutionalization process, depends on actors. According to the Service-Dominant Logic, service innovation is achieved through the recombination of resources leading to a modification of existing value propositions [28] and to the creation, renewal and transformation of pre-existing knowledge, through institutionalization, understood as maintenance, disintegration, change of institution [22], useful for solving problems, developing new forms of knowledge, and also implementing new value co-creation practices [29]. Service innovation is not linked to the mere development of a technology or to the moment in which this is introduced within a context, but it occurs when its introduction determines new practices to pursue the co-creation of value and when these new practices become common and shared [30], and allow the realization of new value propositions and new SES. This approach demonstrates that it is not so much technology as such that favors the survival of the smart city in turbulent conditions. For the smart city to be a valid model for tackling the energy crisis and proposing new solutions, it is necessary that the technologies are developed with a human-centred view to improving the HMIs [31]. Service innovation therefore represents a useful paradigm for tracing future growth paths for smart cities in difficult conditions such as those posed by the energy crisis and to enable smart cities to react quickly and effectively to unforeseen changes.

5 Illustration Case: Digital Twin Cities to Enable Actors to Overcome the Energy Crisis

The digital twin of a city offers great potential in transforming the current urban governance paradigm [32]; it is faithful copy of a city in the virtual world. The severity of the current energy crisis could represent a tipping point for smart cities. The digital twin city would allow policy-makers to remotely monitor the behavior of the real city, plan and develop projects by first observing their effects on the virtual twin in order not to waste resources, anticipate any problems and carry out corrective actions in a predictive way, to effectively implement services offered by the smart city, but also to promptly intercept any energy waste [33]. Through the visualization and analysis of digital prototypes, the urban digital twin allows new opportunities for comparison and dialogue on future urban scenarios of the city between decision-makers and stakeholders. Thanks to this technology, the smart city stakeholders, public, private and society, in general, can follow the behavior of the real city and monitor its evolution, plan and develop projects, observing in advance the effects of their implementation on its "twin", thus preventing the emergence of critical issues [34]. The digital twin technology, through the use of environmental, geospatial and climatic data, makes it possible to create a digital model of the city and was indeed designed to strengthen the analytical capacity of the actors who compose it. The digital twin city, in this sense, complies with a service innovation logic as it aims to enable actors to develop new ways of living and governing the city, therefore new institutions; it could therefore be understood as a driver to navigate the phase transition and as a push factor to self-organization, capable of leading to a re-stabilization through the emergence of new institutional arrangements.

6 Non-conclusive Considerations

We can conclude the work by arguing that service innovation can be an effective driver to enable smart cities, considered service ecosystems, to effectively face the important challenges and uncertainties of our time (**R.Q.**). Thanks to this study, policymakers and smart city scholars can design new city models based on smart technologies capable of enabling the pursuit of viability conditions. The service innovation perspective, understood both in terms of invention and potential diffusion through the institutionalization of new solutions for value co-creation, provide practitioners and scholars with a systemic perspective in resource management and allow them to understand how to survive despite the changes and to be resilient and, maybe, antifragile. Thanks to this vision, they could be able to manage more effectively the unpredictable changes they have to face, such as the current energy crisis. Not only, according to the Sustainable Development Goals expressed in the Digital Agenda 2030, the next challenges of future cities will be linked to the reduction of inequalities and levels of urban energy consumption. It will therefore be interesting to

understand, in future research, how smart cities can contribute to social changes [35] studied by using the Industry 5.0 paradigm, thus investigating how they can respond to the triple imperative of being sustainable [36], human-centred and oriented towards the resilience of industry, economy and society. In this sense, the study of innovation in smart cities according to the perspective of value co-creation [37] can be useful in order to understand which technologies and relational strategies can foster results consistent with this three dimensions.

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